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Grazing Behavior, Forage Quality, and Intake Rates of Livestock Grazing Pastures Occupied by Prairie Dogs

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Objective

Prairie dogs can reduce the carrying capacity on rangelands by up to 50% through direct consumption of vegetation and by clipping plants to improve predator detection. Studies have shown that forage quality and digestibility are greater on prairie dog towns than off-town, however research is lacking that quantifies rates of forage and nutrition intake by cattle grazing pastures occupied by prairie dogs. The objectives of this study were to 1) evaluate relationships between on- and off-town plant communities and cattle grazing locations to identify trends in livestock grazing behavior throughout the growing season, 2) evaluate diet nutrient composition and intake by cattle on plant communities on- and off-town over the grazing season, and 3) study livestock performance in response to level of prairie dog occupation within the pastures.

Study Description

In 2012-2016, a study was conducted in northcentral South Dakota to evaluate livestock grazing behavior, diet quality, and forage intake on three plant communities in pastures occupied by prairie dogs. Plant communities studied were grass-dominated on-town sites (PDG), forb-dominated on-town sites (PDF), and grass dominated off-town sites (NPD). Three pastures with varying levels of prairie dog occupation (0%, 20%, and 40%) were studied. Pasture stocking rates were adjusted to account for the level of forage removed by prairie dogs (50% of on-town forage removed). Each pasture was grazed by a separate herd of yearling steers, a random subset of which were fitted with GPS collars equipped with motion sensors to determine graze locations. Daily time spent grazing was estimated for each plant community and averaged by month for each pasture. Forage quality and intake were estimated using ruminally-fistulated steers that were allowed to graze in 30 minute increments in temporary exclosures within each plant community and pasture for June, July, and August of each year. Rumen diet samples were weighed and analyzed for OM, CP, NDF, and ADL. Intake was calculated as the rate of OM per minute and multiplied by average monthly grazing time based on GPS collar data.

Take home points

Livestock grazing preference decreased linearly on grass dominant sites on-town and increased linearly for off-town sites through the growing season. CP content was significantly higher ($P = 0.002$) on the PDF sites versus the PDG and NPD sites, however, few other differences in forage quality were evident between spatially dominant PDG and NPD communities. OM intake rates

were similar between PDG and NPD communities, however PDF intake rates were reduced 59% compared with off-town sites. Grass dominant communities on prairie dog colonies should be considered as valuable for grazing livestock, but older core areas of prairie dog towns provide no nutritive value to foraging animals. Livestock performance was higher on prairie dog colonized pastures, suggesting that increased diet diversity within pastures colonized by prairie dogs may be beneficial to grazing livestock provided forage quantity isn't limited.

Keywords: forage intake, livestock, prairie dogs

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Abstract

Prairie dogs can reduce the carrying capacity on rangelands by up to 50% through direct consumption of vegetation and by clipping plants to improve predator detection. Studies have shown that forage quality and digestibility are greater on prairie dog towns than off-town; however, research is lacking that quantifies rates of forage and nutrition intake by cattle. In 2012-2016, a study was conducted in northcentral South Dakota to evaluate livestock grazing behavior, diet quality, and forage intake on three plant communities in pastures occupied by prairie dogs. Plant communities studied were grass-dominated on-town sites (PDG), forb-dominated on-town sites (PDF), and grass dominated off-town sites (NPD). Three pastures with varying levels of prairie dog occupation (0%, 20%, and 40%) were studied. Pasture stocking rates were adjusted to account for the level of forage removed by prairie dogs (50% of on-town forage removed). Each pasture was grazed by a separate herd of yearling steers, a random subset of which were fitted with GPS collars equipped with motion sensors to determine graze locations (n = 2 to n = 6). Daily time spent grazing was estimated for each plant community and averaged by month for each pasture. Forage quality and intake were estimated using ruminally-fistulated steers (n = 6) that were allowed to graze in 30 minute increments in temporary exclosures within each plant community and pasture for June, July, and August of each year. Rumen diet samples were weighed and analyzed for OM, CP, NDF, and ADL. Intake was calculated as the rate of OM per minute and multiplied by average monthly grazing time based on GPS collar data. Livestock grazing preference decreased linearly ($P < 0.001$) on grass dominant sites on-town and increased linearly ($P = 0.001$) for off-town sites through the growing season. CP content was significantly higher ($P = 0.002$) on the PDF sites versus the PDG and NPD sites; however, few other differences in forage quality were evident between spatially dominant PDG and NPD communities. Organic matter intake rates were similar between PDG and NPD communities; however, PDF intake rates were reduced 59% compared with off-town sites. Results from this study will inform land managers of potential forage contributions of on-town and off-town plant communities in pastures colonized by prairie dogs.

Introduction

Prairie dogs reduce forage available to grazing livestock through direct consumption and by clipping plants to increase predator detection (Derner et al., 2006). Older core areas of prairie dog towns are often characterized by high percentage bare ground, low vegetation production, and dominance by annual forb and dwarf shrub species; areas more recently colonized typically remain grass dominated (Coppock et al., 1983; Guenther and Detling 2003). Plant community shifts associated with prairie dogs has a potentially large, negative impact on livestock production in the Northern Great Plains.

Derner et al. (2006) showed that an increase in prairie dog town size within pastures led to a decrease in cattle weight gains; however, the decrease was not proportional to the increase in colony size. Although forage quantity is often limited, forage quality has been shown to be

improved within prairie dog town sites (Coppock et al., 1983). At low levels of colonization, livestock diets may be improved as they select a diet from a variety of mature and immature forages on- and off-town provided forage quantity is not limited. While limited research exists on prairie dog impacts on forage quality, even less research has evaluated how prairie dogs impact livestock grazing behavior, nutrient intake, and performance.

In 2012-2016, a study was conducted in northcentral South Dakota to evaluate livestock grazing behavior, diet quality, and forage intake on three plant communities in pastures occupied by prairie dogs. Objectives of this study were to 1) evaluate relationships between on- and off-town plant communities and cattle grazing locations to identify patterns and trends in livestock grazing behavior throughout the growing season, 2) evaluate diet nutrient composition and intake by cattle on plant communities on- and off-town over the grazing season, and 3) study livestock performance in response to level of prairie dog occupation within the pastures.

Experimental Procedures

Study Site. The study area was located near McLaughlin, South Dakota, on a northern mixed grass prairie ecosystem. Predominant soils at the site were clays and loams. Vegetation on the site was largely native. Three pastures at the study site, each approximately 200 ha in size, were established to have varying levels of prairie dog occupation (0%, 20%, 40%). Pastures were grazed continuously by yearling steers from June until early October. Pastures were stocked for similar grazing pressure (animal unit month [AUM]) based on expected forage availability on and off prairie dog towns, adjusted for the percentage of pasture colonized. Three plant communities of interest were identified in the study: grass-dominated off-town locations (i.e. no prairie dogs; **NPD**), annual forb-dominated sites on-town (i.e. prairie dog forb; **PDF**), and grass-dominated sites on-town (i.e. prairie dog grass; **PDG**). Plant community location was mapped using remotely sensed high resolution satellite imagery (Brennan et al., 2019).

Livestock Behavior. Locations and behavior of cattle were determined through the use of Lotek 3300LR GPS collars (Lotek Wireless, New Market, Ontario, Canada) equipped with motion sensors to discriminate between graze and non-graze locations. The collars were set to record a location fix and average motion sensor reading every 5 minutes. Within each pasture, a subset of steers was outfitted with collars and allowed to graze freely. The number of steers collared per pasture varied from n = 2 to n = 6 depending on collar failure. Total number of daily graze fixes within each plant community was calculated for each steer and multiplied by fix interval (5 minutes) to get an estimate of the total daily time spent grazing for each steer in each pasture and plant community within a pasture. For each steer, daily preference indexes (PI) were calculated for each plant community by dividing daily proportion of grazing time in each plant community by the percentage of the pasture the plant community occupied. Daily PI data were averaged by month for June, July, August, and September for each steer within each pasture and plant community.

Diet Quality. Ruminally cannulated steers (n = 6) were used to estimate the nutritive quality and rate of intake of forage consumed by steers grazing in the PDF, PDG, and NPD plant communities. Sampling took place over the span of one week in each of June, July, and August for 2012-2016. Temporary electric fence enclosures were constructed on PDF, PDG, and NPD

plant communities within each pasture the day prior to sampling. On sampling day, steers were herded into corrals and their rumens evacuated based on techniques described by Lesperance et al. (1960) and Olson (1991). Each steer was then transported to and allowed to graze in an enclosure for 30 minutes, after which newly grazed masticate was removed from the rumen. Masticated samples were immediately weighed following collection for rate of intake calculations. A subsample was collected and frozen for diet analysis. Samples were analyzed for determination of DM, OM, CP, NDF, ADL, and IVOMD. All results for diet quality are reported on an OM basis.

Intake. Rate of forage intake (g OM/min) was estimated using the weighed masticated sample from each cannulated steer sampling. Crude protein intake rate (g CP/min) was estimated by multiplying the rate of OM intake by the percentage of crude protein on an OM basis. Digestible OM intake (DOMI) rate (g DOMI/min) was estimated by multiplying the rate of OM intake by the percentage of IVOMD. Total daily forage intake was calculated by averaging steer grazing time from GPS collars for each pasture, plant community, month, and year. Average daily grazing time was multiplied by the rate of forage intake for each corresponding pasture, plant community, month, and year to estimate total daily forage intake (g OM/day). Additionally, average daily grazing time was multiplied by rate of CP intake and rate of DOMI to estimate total daily CP intake (g CP/day) and total daily DOMI (g DOMI/day). Intake preference indexes were estimated using a similar method to grazing behavior PI. Intake PI was additionally calculated for CP intake and DOMI.

Animal Performance. At the beginning and end of each grazing season, unshrunk steer body weights were recorded on two consecutive days for calculation of individual animal performance and production. Average daily gains (ADG) were calculated for each animal (kg/head/day). Total pasture production (kg/ha) was also calculated to evaluate the tradeoffs between animal performance and production per unit of land as a result of reduced stocking rates to accommodate forage removed by prairie dogs.

Statistical Analyses. All statistical analysis was done using SAS (SAS Institute, Cary, NC). PI data, diet metrics (CP, NDF, ADL, and IVOMD), and intake measurements (rate, total daily, and PI for OM, CP, and DOMI) were analyzed as response variables using Proc Mixed. Pasture, plant community, month, and all two- and three- way interactions were fixed effects in the model and year was a random effect. Contrasts statements were used to test treatment comparisons: 1) on- versus off-town plant communities and 2) grass versus forb plant communities. Additionally, orthogonal polynomial contrasts statements were used to test PI for each plant community for a significant linear, quadratic, or cubic relationship with month.
Livestock performance (ADG) and production (kg/ha) were averaged by year and pasture for the 0%, 20%, and 40% colonized pastures. Data was analyzed using Proc Mixed with pasture as a fixed effect and year as a random effect. Orthogonal polynomial contrasts statements were used to test whether performance and production had a significant linear or quadratic relationship with level of colonization (0%, 20%, or 40%).
For all models, the Kenward-Roger option was used to estimate denominator degrees of freedom. When repeated measures were involved, the variance-covariance matrix was chosen

in an iterative process wherein best fit was chosen based on the Bayesian Information Criterion. Least square means and standard errors were generated.

Results and Discussion

Behavior. Results from the grazing behavior PI analysis indicated a significant two-way interaction between pasture and plant community ($P = 0.0005$) and between plant community and month ($P < 0.0001$). Over the duration of the grazing season, NPD preference increased linearly with time while PDG preference decreased linearly with time, and PDF decreased cubically through time (Table 1). Livestock preferred grazing on-town locations relative to their abundance early in the grazing season; however, preference shifted toward off-town locations over time. These results differed from Guenther and Detling (2003) who reported no significant seasonal differences in grazing preference (June- mid-August) for cattle grazing on prairie dog colonies. Guenther and Detling (2003) indicated that cattle significantly selected for prairie dog towns; however, they concluded that the magnitude of the effect was small and likely differed little from random use. Within our study, cattle showed a preference for the PDG plant community, but similarly the magnitude of the effect was not that large.

Diet Quality. CP had a significant plant community main effect ($P = 0.002$). Least square means were: 12.2, 12.4, and 16.2 % CP (SEM = 0.82) for the NPD, PDG, and PDF plant communities, respectively. Contrasts indicated CP was different between on- and off-town ($P = 0.01$) and between grass and forb sites ($P = 0.0004$). Previous research has shown CP and nitrogen content on-colony to be higher compared to off-colony vegetation (Coppock et al. 1983; Johnson-Nistler et al. 2004; Augustine and Springer 2013; Chipault and Detling 2013). While these results appear similar to those observed in our study, the main difference was that the higher CP content was only associated with the forb dominant sites on-colony in our study. It is likely that differences in our results and those of others may be attributed to the methods used in determining forage quality. Previous studies of the quality of forages on prairie dog towns have relied on clipping vegetation by hand, whereas this study examined the forage selected and consumed by cattle. Several studies have shown fistula samples contain significantly more protein than hand clipped samples due to animals' ability to select higher quality diets (Weir and Torell 1959; Bredon et al. 1967; Kiesling et al. 1969). The moderate to low stocking rates maintained on the prairie dog occupied pastures in this study ensured that forage was not limiting, and fistulated steers were likely able to select a higher quality diet than what was generally available to them, even in off-town locations.

All diet metrics had a significant main effect of month ($P < 0.05$). There was an overall decline in forage quality through time. Within a northern mixed grass prairie, Johnson et al. (1998) reported similar declines in forage quality with advancing season (June-December). Results from the ADL, NDF, and IVOMD showed little differences in forage quality between on- and off-town sites.

Intake. All intake measurements had a plant community main effect ($P < 0.05$), and no ($P > 0.05$) main effects of pasture, month, or interactions (Table 2). For OM, CP, and DOM intake rates, there were significant contrasts between on- versus off-town communities and grass versus forb communities (Table 2). The main driver of differences in on- versus off-town was

the lower intake rate for the PDF plant community (9.86 g OM/min). Little difference existed between mean intake rates for PDG and NPD. These results indicate that animals grazing grass-dominated sites on-town were able to consume forage, CP, and digestible OM at similar rates compared with off-town locations.

Comparisons of total daily intake of OM, CP, and DOM indicate that cattle were getting a greater amount of their diet from off-town NPD communities versus the on-town communities. Given that intake rates were similar between NPD and PDG communities, the difference in total daily intake can be attributed to more time spent grazing off-town due to a greater abundance (total area) of that plant community. For the PDF plant community, total OM and CP intake least square means were numerically negative, and all total daily intake values on PDF were not different from zero, indicating that forb dominant sites within prairie dog colonies provide little to no nutrient value to grazing livestock. Within our study site, the percentage of pasture comprised of the PDF plant community was relatively small, but rangelands occupied by prairie dogs with a significant amount of older core areas would likely see a large reduction of carrying capacity for livestock production.

Livestock Performance and Production. There was a pasture effect ($P = 0.0025$) for livestock performance (ADG). Least square means were 0.74, 0.86, and 0.85 kg/hd/day (SEM = 0.03) for the 0, 20, and 40% pastures, respectively. Lack of differences in diet quality and intake rates between the spatially dominant NPD and PDG plant communities suggests that animal performance should be similar across pastures with and without prairie dog colonization. One potential explanation for the difference in ADG observed is that livestock may benefit from increased diet diversity associated with prairie dog colonies. Geaumont et al. (2019), in analyzing species assemblages between on-town and off-town locations, revealed a definitive contrast in vegetation, and concluded that having both habitats on the landscape increases plant diversity at broader scales. At the landscape scale, access to both on- and off-town plant communities may increase diet diversity available to free ranging livestock. Additionally, plant community shifts on-town towards those dominated by shortgrass species have been documented (Koford 1958; Agnew et al. 1986), and are probably attributable to the high grazing resistance of blue grama and buffalograss (Derner et al. 2006). Higher percentages of warm season grasses on-town may further increase diet diversity by expanding the seasonality of high quality forages within pastures occupied by prairie dogs.

Within the context of most grazing studies, climate and stocking rate should be considered. Augustine and Springer (2013) predicted that competition between prairie dogs and cattle is likely with below average precipitation, and facilitation dominates with above average precipitation. Given that rainfall at our study site for four out of five years was above average, forage on-town was likely not a constraining factor and facilitation between prairie dogs and cattle may have occurred. Numerous studies on rangelands have shown that lower stocking rates can lead to increased individual animal performance (e.g. Holechek et al. 1998; Dunn et al. 2010; Derner et al. 2008). Stocking rates were reduced in colonized pastures to account for the amount of forage removed by prairie dogs. Thus, colonized pastures may have been stocked at an effectively lighter rate than the 0% occupied pasture, possibly contributing to differences observed in ADG.

Implications

Producers who manage pastures occupied by prairie dogs have difficult choices to make about maintaining high production and healthy grasslands. Pastures occupied by prairie dogs are commonly stocked (acres per AUM) regardless of the level of colonization. Within this study, stocking rates adjusted for percentage of colonization ensured that forage was not limited and thus reduced competition between livestock and prairie dogs, likely driving some of the responses observed in livestock grazing preference and diet selection. Results from our study, however, indicate that different plant communities associated with prairie dog colonies have different values for livestock. Grass dominant areas on-town were preferred and contributed more to nutrient intake than expected and should be considered valuable by livestock producers. Older core areas of prairie dog towns, however, had little to no nutritive value to grazing livestock, and large areas of this plant community would likely depress nutrient intake by foraging animals. Animal performance results indicate that one benefit of low levels of prairie dog colonization to livestock production may be increased ADG, potentially due to increased diet diversity and seasonality. Though difficult to assess in our study due to reduced stocking rates in colonized pastures, livestock production may only be minimally impacted by prairie dogs at low levels of colonization. Control efforts in these cases may not be beneficial relative to cost, especially if prairie dog towns occupy lower productivity sites within pastures. In pastures with high levels of prairie dog occupation and large proportions of core, bare ground and annual forb dominated communities, livestock production will likely be negatively impacted and grass resources overgrazed if pastures are stocked without regard to level of occupation.

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Table 1: Livestock grazing behavior (PI) least square means and standard errors for results with a significant plant community x month interaction (P <0.05) evaluated on the study site near McLaughlin, South Dakota. The study was conducted during the summers from 2012 to 2016. Plant communities of interest in the study included grass-dominated sites on prairie dog towns (PDG), forb-dominated sites on prairie dog towns (PDF) sites, and grass-dominated sites off prairie dog towns (NPD).

		Month					Contrasts[a]		
	Plant Community	Jun	Jul	Aug	Sep	SEM[b]	Linear	Quad.	Cubic
	NPD	0.796	0.865	0.953	1.1	0.065	0.001	0.321	0.761
PI[c]	PDG	1.726	1.45	1.185	0.856	0.134	<0.0001	0.756	0.814
	PDF	1.358	0.903	0.978	0.412	0.08	<0.0001	0.323	0.0006

[a] Orthogonal polynomial contrasts to determine whether the relationship between plant community and month was linear, quadratic, or cubic
[b] Maximum SEM provided
[c] PI (preference index) calculated as the percentage of daily time spent grazing within the plant community divided by the percentage of area the plant community occupies within the pasture.

Table 2: Livestock intake least square means and standard errors for results with a significant plant community main effect (P <0.05) evaluated on the study site near McLaughlin, South Dakota. The study was conducted from 2012 to 2016. Forage intake rates were collected through the use of ruminally cannulated steers grazing plant communities of interest. Plant communities of interest in the study included grass-dominated sites on prairie dog towns (PDG), forb-dominated sites on prairie dog towns (PDF) sites, and grass-dominated sites off prairie dog towns (NPD). Total daily intake was estimated by multiplying intake rate by average time spent grazing within that plant community estimated from GPS collars. Intake preference (PI) calculated as the proportion of total daily intake from each plant community adjusted for the proportion of the pasture the plant community occupied.

	Plant Community				Contrasts[a]	
	NPD	PDG	PDF	SEM	On vs. Off	Grass vs. Forb
Intake Rate (g/min)						
OM[b]	24.22	22.68	9.86	3.21	0.0002	<0.0001
CP[c]	2.78	2.66	1.54	0.49	0.0019	0.0001
DOM[d]	13.74	13.77	5.95	2.22	0.0042	<0.0001
Total Daily Intake (kg)						
OM	6.00	2.94	-0.41	1.08	<0.0001	<0.0001
CP	0.69	0.34	-0.03	0.14	0.0005	0.0013
DOM	3.49	1.57	0.04	0.66	<0.0001	<0.0001
Intake PI						
OM	0.92	1.25	0.60	0.12	0.962	0.0004
CP	0.91	1.25	0.77	0.15	0.375	0.0492
DOM	0.89	1.31	0.59	0.13	0.5921	0.0003

[a] Contrast: On Vs. Off compared NPD vs PDG & PDF, Grass vs. Forb compared NPD & PDG vs. PDF.
[b] OM is organic matter
[c] CP is crude protein content on an organic matter basis
[d] DOM is digestible organic matter